GENOTYPICAL DIFFERENCES IN WHEAT RESPONSE TO DROUGHT UNDER CONDITIONS OF THE YEAR 2002

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ABSTRACT

Drought is one of the main limiting factors of wheat yield in Romania. The very dry year 2002, allowed a good characterization of the response of many wheat cultivars to water stress, by comparing their performance in yield trials under irrigation and under drought in several locations from the South of Romania. Most Romanian cultivars were relatively more tolerant to drought than most foreign ones tested in the same location. Several new lines exceeded the presently grown cultivars, both in yielding potential and drought tolerance. Although plant height correlated with yield under severe water stress, potential plant height as measured under irrigation showed no correlation with yield under drought. This suggests that breeding semi-dwarf wheat with good tolerance to drought is feasible. The relationship between heading time and grain yield in trials without irrigation was variable, depending on the evolution of water deficit.

Key words: drought resistance, wheat cultivars, semi-dwarf wheat

INTRODUCTION

Drought – insufficient water supply – is an important limiting factor of wheat yields. The climatic changes noticed the last years, with the tendency towards a more arid climate in Romania, have led to an increase of drought frequency in the South, as well as in the Northern half of the country.

Cultivar represents an essential factor in wheat crop management and this fact is evident under drought too. „Choosing tolerant cultivars plays a major role in controlling drought" stated Gheorghe Ionescu-Sisesti, based on the experience of a severe droughty year (1946). Choosing the best cultivar could not guarantee by itself good results under drought, if other crop management measures are not correctly applied. On the other hand, choosing a cultivar inadequate to drought conditions could lead an incomplete use of other crop management investments.

Many researchers studied the differences between genotypes regarding the response to water deficit, underlining the difficulty of combining a high yielding potential with a good tolerance to drought. Thus, Fischer and Maurer (1978) observing that the yielding potential tends to be associated with a higher drought sensibility index (DSI), suggested that some features that are favourable to a high yielding ability could be disadvantageous to drought tolerance. Also, Blum (1996) asserted that „as the stress intensifies, high yielding potential and resistance to drought become incompatible".

In Romania, Saulescu et al. (1998) found a significant correlation between yield under irrigation and drought sensibility index and suggested that the estimation of cultivar behaviour under water stress conditions should be based on deviations from the regression „yielding potential - DSI".

The severe drought of the year 2002 offered an opportunity for a good characterization of the wheat germplasm under testing, which consisted of Romanian and foreign cultivars, as well as new lines at Fundulea and its experimental network.

MATERIAL AND METHODS

An estimation of drought response of several Romanian and foreign wheat cultivars was obtained at Fundulea, by comparing yields from yield trials performed under irrigation and under dry land conditions (Saulescu et al., 1986). A first set of foreign genotypes originated from France,

[1)] Agricultural Research and Development Institute (A.R.D.I.) Fundulea
[2)] Agricultural Research and Development Station (A.R.D.S.) Simnic
[3)] Agricultural Research and Development Station (A.R.D.S.) Valu lui Traian
[4)] Agricultural Research and Development Station (A.R.D.S.) Caracal
[5)] Agricultural Research and Development Station (A.R.D.S.) Teleorman
[6)] Agricultural Research and Development Station (A.R.D.S.) Marculesti

Hungary, Czech Republic and Moldavia. Another set of 64 genotypes from different countries, including Romania, was tested at Fundulea in an experiment co-coordinated by CIMMYT, only under dry land conditions. In this experiment, three to five cultivars or new lines from each country were included. The genotypes originated from Hungary, Bulgaria, Moldavia, Ukraine, Russia, Kazakhstan and Azerbaidjan.

The yield trials with new wheat genotypes were performed in six stations from the South of the country (A.R.D.I. Fundulea, A.R.D.S. Marculesti, A.R.D.S. Valu lui Traian, A.R.D.S. Teleorman, A.R.D.S. Simnic and A.R.D.S. Caracal) and consisted of 25 entries (new cultivars and lines) included in the national testing network.

The experiments were performed both under irrigation and dryland, except at A.R.D.S. Simnic where the testing was performed only under dryland conditions. In this case, the data obtained under irrigation at the nearby A.R.D.S. Caracal were used to approximate cultivar behaviour under no water stress.

Grain yield, the number of emerged plants/m^2, plant height, number of days from 1st January to anthesis, grain filling period, spike number/m^2, grain number/ear and TKW were determined.

Correlation analysis was used to analyze the relationship between traits.

The year 2001-2002 was the driest year for wheat of the last years (Figure 1).

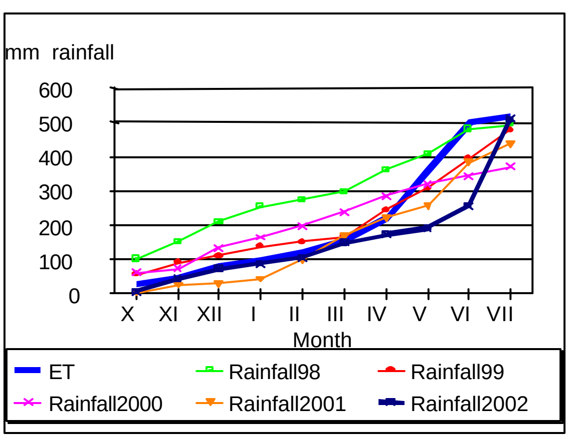

Figure 1. Average evapotranspiration and rainfall during 1999-2002 at Fundulea

The drought began in autumn, winter was mild with low rainfall and the soil water reserve in spring was very small.

At various stations from the South of the country where the yield trials with wheat genotypes were located, rainfall varied both as total amount and as distribution during the vegetation. At Valu lui Traian and Teleorman the water deficit was stronger during the last part of vegetation, while at Simnic and Fundulea the deficit was large during the whole vegetation period (Figure 2).

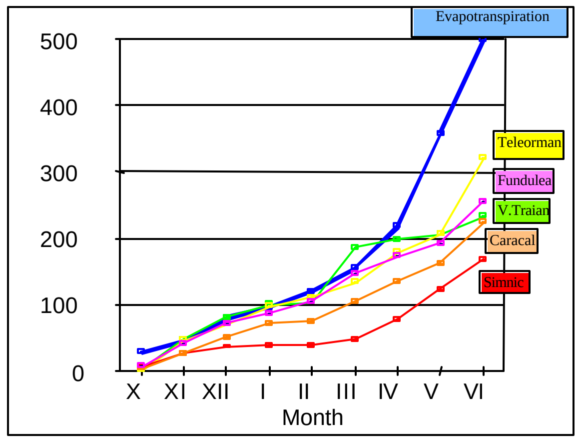

Figure 2. Average evapotranspiration and rainfall during the vegetation period at six locations of Southern Romania in the year 2001-2002

RESULTS AND DISCUSSION

Drought strongly influenced the average yield level of the trials with wheat genotypes, especially under dryland. The average yield varied between 4,700–8,500 kg/ha under irrigation and 500–5,500 kg/ha under dry land conditions. The highest yield reductions were seen at Simnic and Fundulea, under water deficit during all vegetation period (Table 1). The yield reduction was associated with plant height reduction (on average by 27%), reduction of spike number/m^2 (on average by 27%), of grain number/ear (on average by 26%) and of TKW (on average by 22%).

A great variation between locations from the viewpoint of water stress effect on reduction of values for different traits, was found (Table 2).

Table 1. Average yield of trials with winter wheat cultivars, under irrigation and dryland at six locations from Southern Romania (2002)

Location	Average yield under: irrigation (kg/ha)	Average yield under: dryland (kg/ha)	Yield reduction (%)
Caracal	8560	5601	34.6
Marculesti	4716	3075	34.8
Teleorman	5963	3594	39.8
Valu Traian	6941	3794	45.3
Fundulea	4858	1918	60.5
Simnic	8560*	380	95.6

*) Data from the near-by station Caracal

Table 2. Percentage reduction of some plant traits under water stress as compared to the data obtained under irrigation

Location	Plant number	Plant height	Grain filling period	Spike number	Grain/ear	TKW	Test weight
Caracal	0	14.9	15.0	7.9	10.2	14.1	0.9
Teleorman	0	10.0	19.2	12.0	12.0	11.9	1.0
Valu Traian	34.9	21.0	16.9	42.5	12.2	2.9	8.1
Fundulea	4.9	28.8	24.9	6.9	28.9	29.5	3.9
Simnic	27.6	61.7	30.0	65.0	64.5	53.1	10.7
Average	13.5	27.3	21.2	26.9	25.6	22.3	4.9

This variation could be explained by differences in stress evolution, as well as by compensation between different traits.

Plant number was reduced only in two locations, where drought was present from the autumn of 2001. Under moderate stress conditions, a larger reduction of plant and spike number was associated with a smaller reduction of grain number per ear and TKW. Test weight was less affected by drought, probably because smaller grains have a better „packing" efficiency.

The results obtained in testing the first set of foreign genotypes, alongside some Romanian ones, suggest that, although some foreign genotypes gave similar results to the Romanian ones under irrigation (Mv Martina, Mv 04-95, Panos), most of them were stronger affected by drought and gave lower yields under stress than the Romanian cultivars Delabrad, Flamura 85, Alex and Fundulea 4 (Figure 3).

Analyzing the maximum, minimum and average yields obtained by the genotypes from each country, in the international trial with 64 genotypes, one can see that the Romanian genotypes gave, under drought conditions, results that are competitive with cultivars from

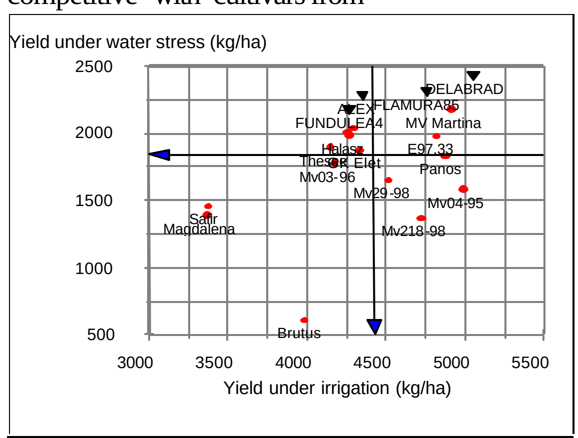

Figure 3. Yield of some Romanian and foreign cultivars with and without irrigation, in 2002 at Fundulea (arrows indicate the average yield of the trials)

South of Russia, Ukraine and superior to cultivars from Bulgaria and Hungary (Table 3).

This good performance of Romanian cultivars under drought are probably due to the breeding scheme applied at Fundulea, which includes the alternation of early generation selection, followed by simultaneous testing, under both irrigation (in order to emphasize the yielding potential, lodging and disease resistance) and under dry land (in order to emphasize drought tolerance). An analysis of the average yields obtained at the stations from the South, under irrigation and under dry land, reveals the fact that some new genotypes had a superior performance under both conditions, as compared to presently grown cultivars (Figure 4). For example, the lines Gloria, Gruia, F95948 and F97266 were among the highest yielding cultivars both under irrigation and drought conditions, significantly exceeding the cultivars Flamura 85 and Dropia, previously noticed for their good performance in dry years (Saulescu et al., 1998). These results suggest the possibility of further progress regarding the combination of a high yielding potential with a good performance under water stress.

Table 3. Minimum, maximum and average yields in the international trials WWEERYT at Fundulea in 2002 for genotypes grouped according to the originating country

Origin	Average yield of the tested genotypes (kg/ha)	Maximum yield of the tested genotypes (kg/ha)	Minimum yield of the tested genotypes (kg/ha)
Romania	2368	2953	2073
Russia	2327	2453	1980
Ukraine-Odessa	2224	3013	1287
Hungary	2181	2780	1320
Ukraine-Mironovka	2108	2753	1500
Moldavia	1927	2560	1293
Bulgaria	1898	2873	1313
Turkey	1893	2420	1487
Azerbaidjan	1460	1553	1367
Kazakhstan	1422	1833	853
LSD 5%	243		275

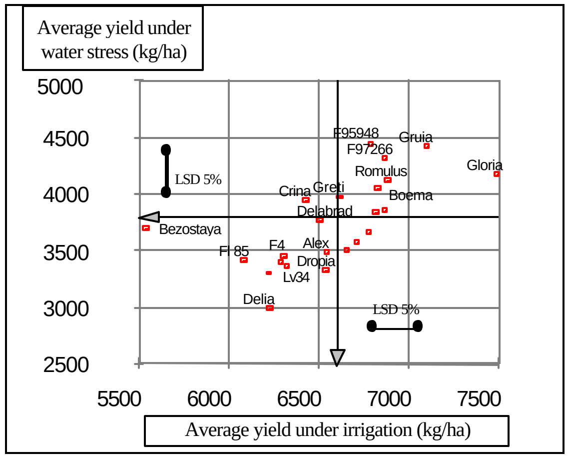

Figure 4. Yields of several Romanian new lines and cultivars, averaged on four locations in 2002 under irrigation and without irrigation (arrows indicate the average yield of the trial)

The correlations between yield under stress and other traits could be useful for defining future breeding strategies. The data obtained in 2002 show that the yield without irrigation was correlated with yield under irrigation only in two out of the five experimental locations, namely those with the lowest stress (Table 4). It is interesting to observe that, even at the highest stress levels, the correlations between yield under irrigation and yield under dryland were not negative, meaning that a good performance under drought conditions was not associated with a low yielding potential.

The trait that showed most frequently a significant positive correlation with yield under drought was the ability to form a higher spike number. These correlations were found both at Teleorman and Valu lui Traian, with strong water deficit at the end of vegetation, and at Fundulea and Simnic with water deficit during the whole vegetation period. The grain number per ear was correlated with yield at the stations with the acute stress (Simnic and Valu lui Traian), while the differences of TKW did not influence yield differences between genotypes under drought.

The correlations between yield under drought and plant height are very interesting. The yield was correlated with plant height only under severe stress conditions, at Fundulea and Simnic (r = 0.41 to 0.46), which suggests that under these conditions the yield depends on the achievement of better vegetative development and larger stem reserve mobilization (Blum, 1998). However, the correlation between the yield obtained under stress conditions and the potential plant height, as measured under irrigation, was not significant at four locations and was significantly negative at Simnic under the strongest water stress. The height under severe drought conditions was not correlated with normal plant height, which suggests that, under severe water deficit, the plant height depends more on stress resistance than on the genes that control the height under optimum conditions. This is important information for breeders, because one could conclude that it is not impossible to release semidwarf cultivars (with good resistance to lodging and high yielding potential in favou-rable years) that achieve a reasonable plant height and give competitive yields under drought.

The relationship between yield under drought and earliness was variable, as mentioned in other studies too (Ginkel et al., 1998). At Teleorman and Valu lui Traian, under strong water deficit at the end of vegetation, a significant negative correlation between heading time and yield was observed, which shows that, under such conditions, the genotypes with early heading gave higher yields than the late ones. At Fundulea and Simnic, with early water deficit maintained during the whole vegetation, there was no correlation, which shows that, under such conditions, the differences in earliness did not influence the yield differences between genotypes under water stress.

CONCLUSIONS

Unusually severe climatic conditions of the year 2002 allowed a good characterization of wheat response to drought. Under these conditions, most Romanian cultivars had a relative good tolerance to drought.

The plant height under normal conditions was not associated with a better tolerance to drought, which suggests the possibility to combine a good resistance to lodging and an increased yielding potential with good resistance to water stress.

The relationship between earliness and performance under drought depended on the water stress evolution, which suggests the necessity to release and grow genotypes of different earliness.

Some new lines proved to be superior to the currently grown cultivars, both regarding the yielding potential and yield under water stress, which underlines the possibility of further progress in breeding for drought resistance.

Table 4. Correlations between yield under water stress conditions and several traits

Locality	Average yield reduction due to water stress (%)	Correlation coefficients between yield under water stress and:						
		yield under irrigation	plant height under water stress	plant height under irrigation	heading time	spike/ m²	grain/ear	TKW
Caracal	34.6	**0.48**	0.29	-0.31	-0.12	0.20	0.11	-0.30
Teleorman	39.8	**0.80**	0.35	0.31	**-0.85**	**0.58**	-	-
Valu Traian	45.3	0.04	0.33	0.20	**-0.40**	**0.42**	**0.40**	0.22
Fundulea	60.5	0.00	**0.46**	-0.31	**-0.46**	**0.52**	0.30	-0.17
Simnic	95.6	-0.01	**0.41**	**-0.62**	-0.04	**0.40**	**0.50**	0.15

Coefficients written with bold characters are significant at the probability level of 0.05

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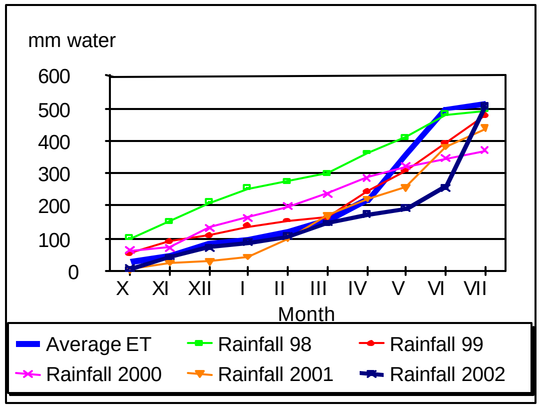
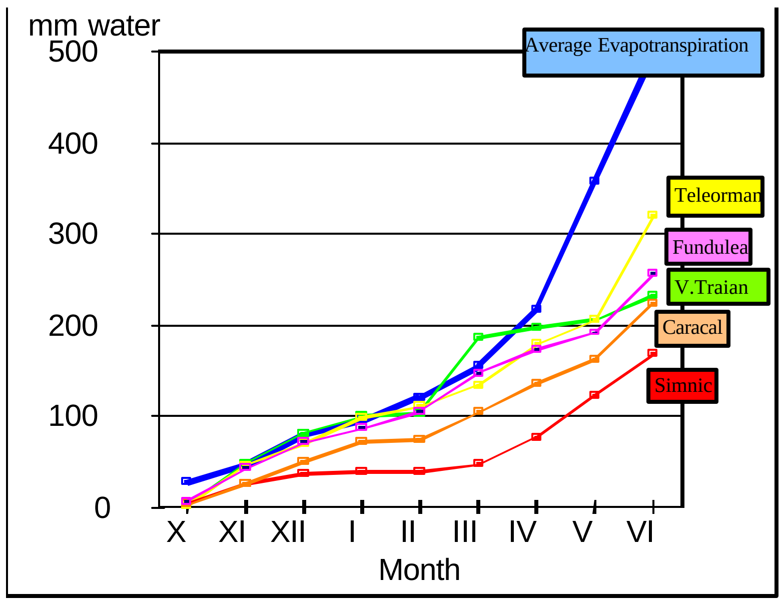


Figure 1. Average evapotranspiration and rainfall during 1999-2002 at Fundulea



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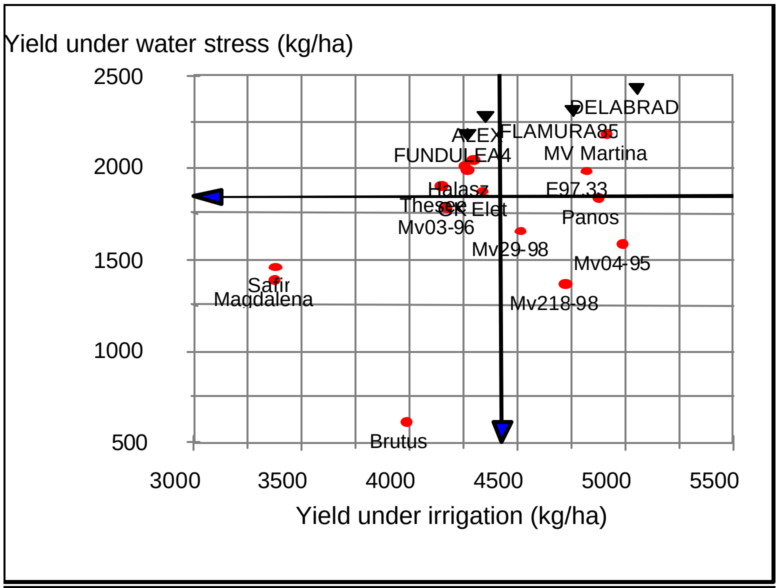

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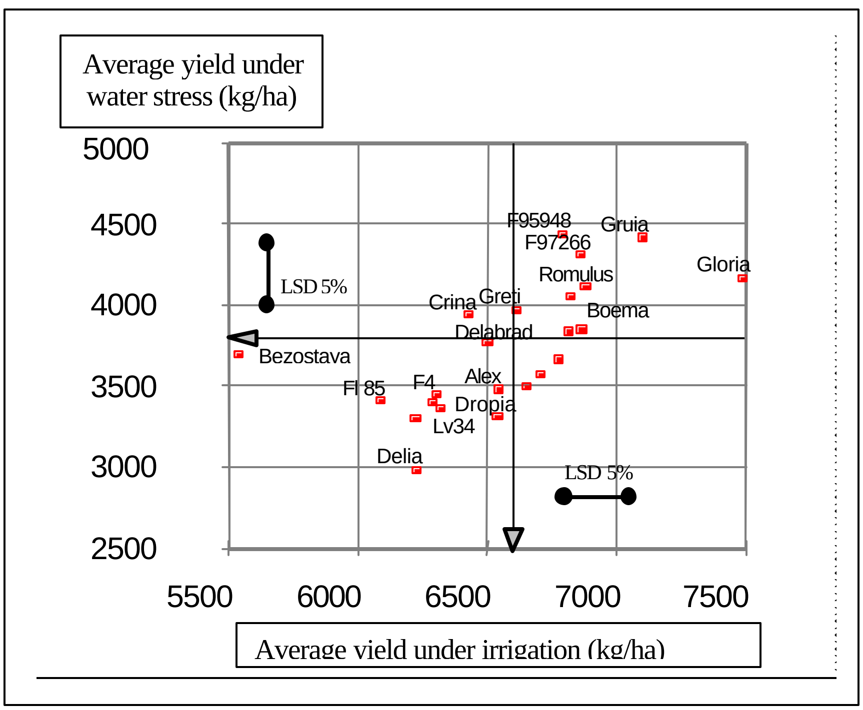

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